Form ESA-B4. Summary Report for ESA-168-3
Public Report - Final

Company	Hercules, Inc. - MCW	ESA Dates	September 09-11, 2008
Plant	Louisiana, MO	ESA Type	Steam
Product	Chemicals & Synthetic Lubricants	ESA Specialist	Riyaz Papar, PE, CEM

Brief Narrative Summary Report for the Energy Savings Assessment

Introduction:
The Hercules, Inc. – Missouri Chemical Works (MCW) plant is located in the city of Louisiana, MO on the Mississippi river. It was the focus of a 3-day steam system Energy Savings Assessment (ESA). The plant was built in 1941 to manufacture gunpowder for World War II, but currently serves as a Paper Technologies and Ventures (PTV) business for Hercules, Inc. The plant currently manufactures a slow release fertilizer (Nitroform), Formaldehyde, Pentaerythritol (PE) and synthetic lubricants for use in several industries. The plant has a central Powerhouse that uses midwestern coal and supplies steam and electricity to the entire plant. The Powerhouse generates superheated steam at 400 psig (750°F) and generates ~9 MW of power using single extraction-condensing steam turbines. Steam is pressure reduced to 225 psig and 50 psig and supplied to the entire plant. Steam is also exported at 400 psig to a neighboring plant for their start-up operations only. Make-up water for the boilers is pre-heated by the neighboring plant and that is a another indicator for good site level integration even across the fence lines.

Typically, process heat load is directly production dependent and has minimal impact due to seasonality. Nevertheless, the plant steam load does have a winter and summer operating profile. The main difference between the summer and winter steam loads is due to the cold river water temperatures in winter. The MCW plant also has a raw water plant which supplies ~2 million gallons per day that is needed for the overall plant. There is a good level of sub-metering for steam usage at the Powerhouse. Plant personnel do an excellent job in tracking coal usage and steam demand on a monthly basis and provide this information to management.

Objective of ESA:
The main objectives of the ESA were as follows:

- Identify steam system energy savings opportunities for the MCW plant steam system
- Use the DOE Steam tools such as the Steam System Scoping Tool (SSST), System Assessment Tool (SSAT) and the 3E Plus insulation software to model the steam system at the plant
- Assist plant personnel to gain familiarity and use all the above mentioned tools to identify energy efficiency improvement opportunities at the plant and quantify the energy savings associated with the steam system

Focus of Assessment:
Steam system at the MCW plant, Louisiana, MO

Approach for ESA:
The ESA core plant team included the following personnel: Keith Ball (Sr. Reliability Engineer), Bob Lee (Powerhouse Supervisor), David Volpe (Production Lead) and Tim Maryak (Process Engineer – Macon plant). These people have varied responsibilities for the steam system ranging from energy system optimization, operations, maintenance and reliability. During the ESA, support to the team was also provided by Doug Ivari (PE Operations Leader) and Robbie Scott (Maintenance Leader) to better understand steam usage in the Powerhouse and the plant. The team first completed the Steam System Scoping Tool (SSST) at the start of the ESA and this helped the ESA Specialist understand the plant's steam system in detail.

The results from the SSST had indicated several possible opportunities in the Boiler Plant Operating Practices area and so the ESA core team spent significant time during the ESA walking and inspecting all the facets of the steam generation system. Nevertheless, the core team did complete walk-throughs and meetings with key personnel in the distribution, end-use and recovery areas. All throughout the walkthrough, a state-of-the-art infra-red thermographic camera was used to assist the team in the steam assessment. This significantly enhanced the quality and level of the steam ESA. These infra-red cameras were not only used to evaluate insulation opportunities in the plant but also to evaluate steam trap operations, steam flow, etc.

During the ESA, the plant lead had organized a "Lunch & Learn" to provide the core team and interested plant personnel with an overview and usage of the DOE's Steam BestPractices Tools Suite. This was very well attended. Plant personnel were not able to install the DOE softwares on their machines during the ESA due to IT security permissions. Nevertheless, they have already requested those permissions and will install the software on their machines. The SSAT model was used to quantify the potential energy savings opportunities at the plant. A 3-pressure header system template was used to model the steam system at the plant. The core team used "2007" as the base year and collected all the necessary data required for use in the SSAT model from the monthly averages for the period January-December 2007.

General Observations of Potential Opportunities:
There is a high level of industry BestPractices in place at the MCW plant and it is reflected in the score (75%) that the plant received on the SSST. One area that the plant scored lower than the average was in Boiler Plant Operating practices and hence, more emphasis was laid on the PowerHouse operations during this ESA. As mentioned earlier, although the plant steam demand has a summer and winter load profile, it was decided that average monthly data of 2007 be used for the ESA analysis. Hence, one 3-header SSAT model was developed for completing the ESA analysis. Plant personnel can take this model and develop it for the two seasons or on a monthly basis subject to their needs.

There are three pulverized coal water-tube boilers (#1 - 3) at the Powerhouse and all of them have combustion air preheaters. The boilers are fired by Midwestern coal and have the capability to run on #2 fuel oil as a backup. Each boiler has a capacity of producing 140 klb/hr at 400 psig superheated steam (750°F) conditions. Average plant steam demand is ~210 klb/hr. The Powerhouse also has two multi-stage single extraction condensing turbines. Each turbine is rated at 8.6 MW. Steam is supplied to the entire plant via two headers: 225 psig and 50 psig. A pressure letdown station balances the 225 psig header and the turbine extraction balances the 50 psig header steam demand.

Typical annual plant operation hours are ~8,500 hours. The annual fuel (coal) usage at the MCW plant is ~125,000 tons. The average annual coal cost is ~$71 per ton. This average coal cost is used as the impact cost for all the analysis in the ESA. On the electric utility side, the average plant demand is ~9 MW and the plant aims to produce as much electricity as possible to offset importing power from the local grid. Annual electricity purchased from the utility grid was ~32,000,000 kWh. Fully bundled average electric utility cost is ~$0.05 per kWh.

Based on the Steam ESA, energy savings opportunities do exist in the overall steam system at the MCW plant. These energy savings opportunities are quantified in the table on Page 1 and are described briefly below and identified as Near, Medium and Long term (please refer to the definitions at the end of the report).

1. **Improve Boiler Efficiency - Implement Positional Excess Air Control (Near Term Opportunity)**
   The boilers currently do not have flue gas oxygen monitors. Based on actual readings taken by plant personnel using portable combustion analyzers, it was found that the boilers operate at ~10% flue gas oxygen. Since there are no specific controls, a positional controller with proper retuning of the combustion side is recommended. This would reduce the flue gas oxygen to levels around 5-7%. Implementing this opportunity would change the boiler efficiency from the current - 83.5% to an improved – 85.8%. Plant personnel have started taking steps towards this measure but full implementation and monitoring of flue gas oxygen has still to be incorporated.

2. **Improve Boiler Efficiency - Implement Automatic Oxygen Trim Control (Near Term Opportunity)**
   After implementing the energy savings opportunity listed above, an additional recommendation for further improving the boiler efficiency is to use automatic oxygen trim controllers on the boilers. These allow for very tight flue gas oxygen (or excess air) control. State-of-the-art industry BestPractices indicate that for pulverized coal-fired boilers, flue gas oxygen levels can be controlled within 2.5-4.0%. From an efficiency perspective, implementing automatic oxygen controls can improve the efficiency to ~87.3%. Using the SSAT model, incremental energy and cost savings beyond the first energy savings opportunity have been provided in the table.

3. **Other - Install VFDs on Forced-Draft Fans (Near Term Opportunity)**
   The forced draft fans on all the boilers are damper controlled. Each fan has a 100 hp motor and typical operation shows that the boiler operation modulates between 25-75% of firing. This implies that there can be electrical energy savings by converting the single-speed forced draft fans to Variable Frequency Drives (VFD). First level energy savings analysis was done using the fan affinity laws and observed amperage data and boiler loading.

4. **Implement a Steam Trap Maintenance Program (Near Term Opportunity)**
   It is found that ~10% of traps fail in the industry every year and repairing or replacing these traps will lead to energy and cost savings. Since there are several traps that end in atmospheric condensate tanks, a good

indication of trap failure is receiver vents. The Powerhouse personnel are already working towards developing a world-class steam trap maintenance program which includes proper trap selection, steam trap database, annual inspection of all traps for performance and an immediate repair/replace procedure for failed traps. Note that although the ESA did not allow for a detailed steam trap audit, all throughout the walkthrough infra-red thermography was used to check trap operation and verify performance. The SSAT model was used to estimate potential savings opportunities.

5. Implement a Steam Leak Maintenance Program (Near Term Opportunity)

Although the ESA did not allow for a detailed steam leak audit, every effort was done to capture and quantify steam leaks during the Powerhouse and plant walk-through. Based on information collected, a preliminary evaluation of the amount of steam leaking to ambient was calculated and then the SSAT model was used to quantify the savings potential. The main areas of steam leaks that were observed included – 225 psig header leak at Powerhouse, valve stems and packings, safety relief valves, steam traps, deaerator overhead condenser, etc. Hence, it is strongly recommended that the plant personnel undertake a steam leak audit and try to eliminate steam leaks across the plant site.

6. Other – Block-in unused 400 psig supply header (Near Term Opportunity)

There is a 400 psig steam distribution header (10 inch) that runs ~1,500 ft from the Powerhouse to the neighboring plant across the MCW plant fenceline. The block valve on this header is at the neighboring plant's process usage. Hence, this header remains hot all year round even though steam usage is only required for occasional startups at the neighboring plant. Though the header is insulated it can still lead to a significant energy loss due to cold ambient conditions, rain, etc. The 3EPlus insulation program was used to estimate this energy loss and savings were calculated based on using an isolation valve at the Powerhouse for blocking in.

7. Add Backpressure Steam Turbine (Medium Term Opportunity)

Currently, superheated steam is generated at 400 psig and reduced to 225 psig for plant usage using a pressure letdown station. Implementing a back pressure turbine at the Powerhouse will produce power and simultaneously reduce the steam pressure for plant usage. Based on 225 psig steam usage (45.6 klb/hr), and using the SSAT model, ~375 kW of power can be generated from the backpressure turbine(s). An additional optimal approach would be to directly drive one or more mechanical equipments (pump, fan) with the backpressure turbine(s) rather than generating power.

8. Change Boiler Blowdown Rate (Medium Term Opportunity)

Based on water chemistry logs maintained by operators and a recent report on blowdown, average boiler blowdown was found to be ~10-15%. Nevertheless, it is required to maintain proper boiler water chemistry. Water treatment at the MCW plant consists only of water softening and considering the entering raw water quality and the boiler pressure, it is recommended to improve the water treatment capability at the plant.

The boilers currently have manual blowdown valves that are adjusted based on boiler water conductivity. This leads to excessive blowdown. An automatic blowdown controller measures conductivity continuously and modulates a blowdown valve thereby blowing down only the amount required at that time to maintain boiler water chemistry. This will result in water savings and additional cost savings. The SSAT model was used to model the savings potential by reducing the blowdown levels to 2%. It has to be noted that both flash and sensible heat recoveries from the blowdown flash virtually eliminate excess fuel usage with higher blowdowns.

9. Other Opportunities & BestPractices

During the course of the ESA, there were other opportunities that were briefly investigated but a much more detailed due diligence is required to quantify energy savings and implementation. Additionally, some bestpractices that can be put into practice immediately are also mentioned in this section.

- <u>Plant-wide Insulation Appraisal (Near Term Opportunity)</u>

Overall, the insulation at the plant is good but there are certain areas that may benefit from improved insulation practices. These areas include certain sections in the Powerhouse (steam and mud drum inspection flanges, valves, etc.) and distribution. Surface temperatures in some of these sections can be as high as 750°F. The 3EPlus insulation program was used to estimate the energy loss from un-insulated areas. A 12-inch pipe can cost as much as $360 per linear ft annually in fuel costs if it is not insulated. A vertical surface can cost as much as $105 per square ft annually if it is not insulated. It is recommended to do a plant-wide insulation appraisal using the state-of-the-art infra-red thermography cameras since it was out of the scope of this ESA.

- <u>Improve Condensate Recovery Rates (Near Term Opportunity)</u>

  Although there are several bestpractices in place including using condensate heat recovery and use of condensate as process water, there are still certain areas that can be targeted for condensate recovery. One of those areas includes distribution header steam traps. Determining an exact improvement in condensate recovery rate was out of the scope of this ESA, but every "lb" of lost condensate has to be made up by a "lb" of make-up water and that is extremely expensive. Hence, there are several penalties apart from the thermal energy loss including but not limited to, chemical treatment costs, water cost and sewage. The SSAT model indicates that improving condensate recovery by 1 klb/hr (2 gpm) can save ~$5,000 annually for the plant.

- <u>Implement real time monitoring and add trending of efficiency (BestPractice)</u>

  The Powerhouse currently has good data monitoring. This provides a good opportunity to collect critical data and allow for calculations of equipment efficiencies on a routine basis. This will allow for tracking performance and would help to predict any upcoming maintenance issues. For example, boiler efficiency, condensing turbine efficiency, etc. can be calculated real-time and trended. The Powerhouse should also calibrate all the instruments so that the data recorded has a high degree of accuracy.

Management Support and Comments:
From a corporate standpoint, Hercules, Inc. has not set any annual energy reduction targets or goals. Nevertheless, plant management provided full support to the core team to capture any and every economically justifiable opportunity. Additionally, the Plant Manager (Walter Crenshaw) attended the "Lunch and Learn" event during the ESA and provided insight and support to the core team. The core team spent three days working with the ESA Specialist and will continue to work on identifying projects plant-wide thereby re-affirming their goals and strategy.

Lastly, Tim Maryak (from the Macon, GA plant) participated as a core team member in the ESA. In his role, he would take all the lessons learned from this ESA to apply to the Macon plant as well as other Hercules, Inc. plants. This clearly shows the corporate commitment and culture of cross-cutting Bestpractices implementation across all plants.

DOE Contact at Plant/Company: (DOE would contact for follow-up regarding progress in implementing ESA results.)

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The definitions for Near Term, Medium Term, Long Term opportunities are as follows:

- Near term opportunities would include actions that could be taken as improvements in operating practices, maintenance of equipment or relatively low cost actions or equipment purchases.
- Medium term opportunities would require purchase of additional equipment and/or changes in the system such as addition of recuperative air preheaters and use of energy to substitute current practices of steam use etc. It would be necessary to carryout further engineering and return on investment analysis.
- Long term opportunities would require testing of new technology and confirmation of performance of these technologies under the plant operating conditions with economic justification to meet the corporate investment criteria.